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# Supply Chain using Smart Contract: A Blockchain enabled model with Traceability and Ownership Management

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**Abstract**—The concept of openness and decentralization is one which people have desired since years. Everyone wants transactional data to be transparent. When sensitive data are on the hand of third-parties, it may be susceptible to frauds and misuse. The advent of blockchain, a decentralized technology in cryptocurrency, has revealed an appropriate solution to address such issues. Blockchain maintains the integrity of a transaction. It not only secures from tempering and fraud but also ensures transactions are verifiable without involvement of an intermediate. Therefore, blockchain is applied to different decentralized domains that require trusted computing. Supply chain is one of these domains, that can benefit from trustworthy decentralized transactions initiated by multiple stakeholders. This paper presents a general model for a blockchain enabled supply chain. We have implemented this model using three smart contracts on an Ethereum platform. We have provided evidence of our verification and validation efforts. Our results convey the feasibility of the approach, which can streamline the administrative processes, and automatize the transactions making the system more efficient and transparent.

**Index Terms**—Blockchain, Cryptocurrency, Supply chain, Smart contract

## I. INTRODUCTION

The primary purpose of this research work is to develop smart contracts for a transparent and traceable supply chain. This research aims to explore the adaptation of smart contract to develop a supply chain model that would digitally facilitate, verify and enforce the negotiation of a contract. Supply chain involves multiple processes from the procurement of raw materials, to processing or production by manufacturers, delivery of finished product to end users, and post-sales support. It is required to integrate these steps and the stakeholders to make an effective supply chain [1]. There are several challenges, which make the management of such process complex [2]. It is very difficult to explore incidents happening in a supply chain and track events and information about an incident due to loss of information caused by probable sophism in every step of the chain. There is no dependable way to track the transactions for any reasons like issues related to insurance claim or identify provenance, know the reliability of a service provider or receive product related information as we need to depend on a centralized system [1]. It is always hard to investigate unlawful activities of a stakeholder in the supply chain and make them accountable for what they do. Even it is

difficult for other stakeholders to get information about another concerned stakeholder.

Supply chains demands transparency of transactional data, traceability of products and security concerns throughout its lifetime from provenance to disposal [1]. For achieving these characteristics, the concept of managing supply chain should be taken to a new level of maturity. An effective supply chain allows to provide feedback of the stakeholders and allows to consider their reputation before doing any transactions. Most existing networks cannot address legal questions regarding data sovereignty and fail at the creation of reliable end-to-end communication. It makes the stakeholder aware of customers need and help in demand management by adding values to the overall process. It ensures effective communication of transactional information and makes the management efficient and productive. Adam [3] presents a case study on the retailer Walmart that showed the integration of each transactions helps stakeholder to reduce associated costs which plays significant role in successful management of supply chain. Such effective collaboration fortifies relationships among stakeholders and make them more responsible.

Blockchain technology enables to develop a supply chain with above features. This technology was first invented as the backbone of Bitcoin in 2009 [4]. This revolutionary innovation has several possible extensions that could precise outcomes to change computational domains far beyond crypto currency. It can be implemented together with a computer protocol called smart contract to trigger an event when a pre-coded condition of a contractual agreement is happened. It simplifies the registration, verification and execution of each transactions. Several advancements have been made in the implementation of blockchain and smart contract in new domain of applications including identity certification, legal contracts, supply chain, intellectual property rights, property ownership and health services [5] [21]. In all these domains, smart contract is the most promising application for better traceability while maintaining transparency and privacy. Companies like IBM, Samsung, Amazon and eBay are also exploring alternative and novel uses of these technologies for their own applications including supply chain [6].

Blockchain allows to securely store a unique digital identity of the product along with its physical properties, in different

form such as serial number, to the wallet of the owner [1]. Records stored in a blockchain are immutable, no one can manipulate, alter or duplicate data. Only valid transactions can take place. For supply chain, blockchain technology makes it possible to follow and track every product to the provenance of raw materials, including a valid timestamp. In this paper, a model for a supply chain that is supported by the blockchain technology is presented. The proposed model describes the interaction between four relevant stakeholders of a supply chain namely the Central Authority, Producer, Carrier and Wholesaler. This model has been partially implemented with three smart contracts in Solidity on the Ethereum Blockchain Platform. Evidence of the verification and validation is presented, showing the feasibility of the proposed approach. Through this approach, transactions are automatized to ensure data transparency and traceability. Several use cases are presented to convey how smart contract can control honest behaviour among the stakeholders participating in supply chain. The bidding process is made more transparent and payment procedure is also automatized. Tracking of product is possible and provenance of product can be determined easily.

This paper is structured in following way. The context of proposed work is discussed in the introduction section. Next to this section, literature review is presented in the form of an overview of blockchain, smart contract and related work on implementation of these technologies in supply chain domain. In section III the proposed model and framework is introduced, highlighting the traceability and ownership management concerning the incorporated interoperability. Section III emphasizes more on the blockchain technologies within the proposed paradigm, and finally, the discussion of the research work in section IV.

## II. LITERATURE REVIEW

### A. Blockchain and Smart Contracts

Blockchain technology provides an open, distributed ledger that can record transactions between two parties securely and efficiently in a verifiable immutable way [6]. It incorporates encryption to maintain security. It uses public-key cryptography to create an immutable chain of blocks of transactions. Blockchain technology has been successful in supporting cryptocurrencies. In addition to immutability, another key aspect of the technology is decentralization. It is managed by a distributed network of nodes. A node is a computer that is connected to a network and acts as a stakeholder. When any new node connects to the network after approval, initially it downloads a full copy of the blockchain database. Active nodes receive the information of pending transactions and verify those before adding to the database. There are set of rules agreed by the participant nodes based on which they analyse the validity of each transaction. All valid transactions are added to system in the form of blocks and updated after each transaction, in a way that resembles a chain, hence the name blockchain. The transaction starts with the creation of a first block which is marked with a hash function. The second block is created when there is an update in the first block.

When a node alters any of the transactions included in the previous block, the hash function of the block is also changed while submitting the block in the chain, which includes part of the first blocks hash function [6]. All other nodes will be able to detect that a change has been made and gets the update. This fundamental functionality of blockchain is what makes a blockchain database secure.

A block contains main data, hash of previous block, hash of current block, timestamp and other information defined by the user. The main data in a block depends on the type of service and application. It may be transactional record or property record or ownership record. To maintain the security information is hashed and included in the block. Time of block generated is also included in each new or modified block. User can define information like transaction count (nonce), value, policies etc and include in the block.

Smart contract is a self-executing computerized transaction protocol that intends to facilitate and enforce the negotiation of an agreement. It is deployed in a decentralized Blockchain network like Ethereum and is visible to all the nodes. It can be defined as digital script that can encode any set of rules represented in the form of code with its correctness enforced by the consensus protocol of the Blockchain. Each contract is identified by its address, computed in a deterministic way from the address and the transaction count (nonce) of its creator. Each node of the Blockchain can participate in the transactions to the smart contract. Then, as detailed in [23], all stakeholders of the network execute a set of rules coded as terms for contract with the current state of blockchain and the transaction payloads as inputs. After the transaction is verified, by participating in a consensus protocol, the smart contract is triggered which outputs the next state of the contract.

Currently researches are ongoing on the implementation of blockchain technology in different computing domains besides cryptocurrency because of its decentralized open and public nature. Blockchain technology and smart contract can be combined to create a distributed computing platform for several processes (e.g. eBay, uber etc.) [19]. Microsoft is also exploring the use of smart contracts to streamline future business operations. It has developed block chain as a service system in its Azure Platform for the experimentation of its new business processes [19]. In 2014, Foroglou et al. [21] has shown the possible advantages of blockchain technology in domains like smart contracts, smart property, finance and intellectual property. When we require transactional privacy in our system it is also possible while using this technology. Kosba et al. [22] presented a decentralized smart contract system, called Hawk, which ensures privacy of transactional data. This model ensures filtering the data which does not requires to store in the blockchain and showed that blockchain enables data privacy and security.

Smart contract and blockchain technology enables to develop a supply chain which is more efficient, secured and traceable because the consequent actions are triggered after the environmental conditions are verified. On top of traceability of the product, using smart contracts, transactions are made

transparent and determining provenance is made possible. In this paper we use the introduced smart contracts for this proposed model. This is built upon the Ethereum platform using Solidity which is a type of high-level language exclusively used to program such contracts.

### B. Application of Blockchain to Supply Chain

Supply chain is an essential element of business world. There are many challenges associated with this domain in both planning and coordination stage. An uncertainty of consumer demand for product creates disparity in supply and demand and inventory management [2]. Stakeholders can manipulate the information in their own way as the system is not decentralized so this creates unevenness in the transactional data. There are some forecast models [7] developed to manage such challenge to identify and response such disruptive events. The lack of collaboration to share transactional information generates the issue of traceability. The reliability and efficiency [8] [9] of the supply chain is always a big challenge.

In 2010 Akkerman et al. [10] worked in the Agri-food supply chain management for quality and safety control through transparency. In 2016, Tian [11] purposed an agri-food supply chain traceability system, based on RFID and blockchain technology. The research shows that RFID technology can be used in logistic industry to collect information and manage it for monitoring, tracking and security. This model ensures trusted information sharing and realizes the traceability which eventually guarantees the quality and safety of agri-food products, but it stays silent about automation of overall process. Companies like Walmart, Maersk, and Everledger have started exploring the use of smart contracts to track a diverse range of goods, including meat, shipping containers, mining samples, and even diamonds [12]-[16]. Maersk has a system to track shipping containers and prevent tampering of shipping documents [13]. Walmart has a system to track the transportation of pork from Chinese farms to stores, and products from Latin America to the United States [12, 13]. Everledger uses blockchain technology to track the provenance of diamonds and their conveyance from mines to stores [18]. Modum.io, a Swiss company has a smart contract system to track the environmental conditions during shipment of medicines [20].

Most of these studies consider tracking of product using smart contract. They have concentrated on the determining provenance of product. The effectiveness of using smart contract in supply chain is not only limited to determine provenance or tracking product. Along with these, we can build smart contract to automatize the bidding procedure making it more transparent and reliable and automatically trigger the payment after the contractual agreement are met. In this paper, a supply chain is developed with blockchain enabled bidding system with traceability and ownership management. This smart contract will improve the efficiency and reliability of the supply chain making the transactions more transparent and significantly make it reliable as the triggering of events depend on pre-set contractual parameters.

## III. DESIGN OF BLOCKCHAIN ENABLED SUPPLY CHAIN MODEL

### A. Overview

A proof-of-concept is proposed that uses blockchain and smart contracts to model a supply chain system. A supply chain model is developed that makes possible to determine the provenance of product, track product in the chain and make transactional data available to all stakeholders. Supply chain is automated by smart contracts which run on a blockchain that all stakeholders are able to access. Each stakeholder is required to record updated transactional details to the blockchain. Furthermore, a reputation score can be recorded which can be calculated from the digital reviews for successful transactions. This reputation is used by the smart contract to identify a more reliable stakeholder. The transparent ledger appeals stakeholders to help build trust with in the network and to work towards maintaining a good reputation.

### B. Proposed Model

Fig. 1 shows a model of supply chain with major stakeholders each of which plays different roles by providing relevant information of the product. Each product is represented by a unique digital identifier which can be mapped to relevant information which is updated at different stages in the supply chain. Stakeholders presented in Fig. 1 are:

- The central authority (CA) provides unique identities to other stakeholders, define standards schemes and provides certifications to them for participation in the network. Upon registration, all stakeholders are given their own digital profile such as location, certification, and associated products on the network. CA can generate a cryptographic pair of public and private key for each stakeholder which can be used by them for their identification and authentication in the network for any transactions.
- The producer, distributor, wholesaler and retailers enter product specific data in blockchain at different stages.
- The carrier transports product from a stakeholder to next.
- The consumers purchase products and can enter product data to the blockchain. They can be the End User who can verify the product s/he is using.

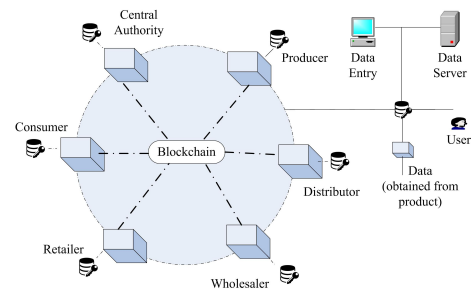


Fig. 1. A blockchain enabled supply chain.

To systematise supply chain, multiple exchanges of information are needed from financial to goods or services. The needs and objectives of each stakeholder must be understood

before a supply chain can be systematised. For instance, producer assigns a contract to a carrier by accepting a bidding request who meets the bidding criteria (which is exchange of information). These transactions are generated and evaluated to systematize supply chain. These elements play role for ownership management, traceability, transparency and security of supply chain. Systematization of supply chain requires multiple artefacts being shared among stakeholders. Each stakeholder need to capture every event. Blockchain is able to create, update and inform stakeholders when any event occurs.

In this research, we are scoping supply chain to interaction among three stakeholders (producer, carrier and wholesaler). A descriptive form of this blockchain-enabled supply chain is illustrated in Fig. 2. The following section presents a proof-of-concept developed and deployed to Ethereum. Through blockchain any stakeholder can obtain information regarding provenance, owner identification, track elements in supply chain, and recognize reputation of a stakeholder. Fig. 3 describes a scenario for this supply chain. Producer forwards a quote with terms and conditions following which wholesaler makes a purchase order. Producer issues sales order. Further, producer broadcasts bid and initiates smart contract mentioning terms of agreement. All carriers get notification about the tender. It contains relevant information like quantity and quality of product, last date of bidding, loading/unloading location, tentative date of loading, distance of travel etc.

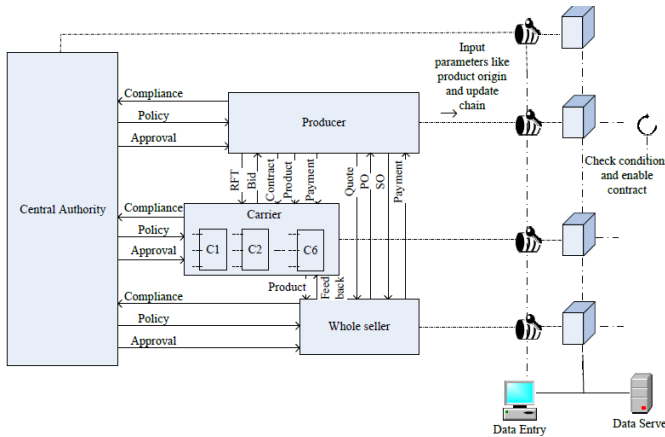


Fig. 2. A model of a Blockchain-enabled supply chain.

Carriers take part in bid by depositing some amount. Bid amount must be less than the maximum bid value initially set by producer. For Bidding Contract, owner of the contract will assign an arbitrary value for reputation factor to different carriers. In further work we intend to collect reputation points for each carrier and analyse these points in similar way as now it is done with the arbitrary reputation factor. The carrier who meets reputation requirement and bids the lowest amount wins the tender. Bid amount and reputation factor are considered as trigger event for smart contract. Deposit made by other carriers is released. The producer sends delivery via the winner carrier who transports product to whole seller. Producer updates block information after it handover product to the carrier. Payment

is released but the function holds it from getting added to the wallet of the carrier before the updates of successful receive of goods is made. All participants other than the winner get their deposit reimbursed. The carrier delivers good and update information in the block. Wholesaler receives delivery and checks the status of product, verifies it from the information in the block and updates successful receive in the block. Payment from producer to carrier will be executed after the whole seller updates the received information. Deposit made by the winner carrier is also released. Whole seller and even producer can add feedback to the system by providing certain points to the carrier which can be considered for future transaction with the carrier. This is considered as the reputation of the stakeholder.

### C. Implementation of smart contract enacting a supply chain

Smart contracts in this research work are written in Solidity. Development is done using Remix, a browser based Solidity compiler. To enact interaction among the stakeholders described in previous section, three smart contracts are developed. Provenance Contract to know the details of producer or product, Bidding Contract to automate the bidding process and Tracking Contract to track products. They play role to maintain transparency of different transactions made among the stakeholders and automatize the network. The roles and responsibilities of stakeholders is presented in Table I. Tables II to IV present the relevant functions of these smart contracts. Stakeholders interact with these contracts by instantiating and deploying the contracts to the blockchain.

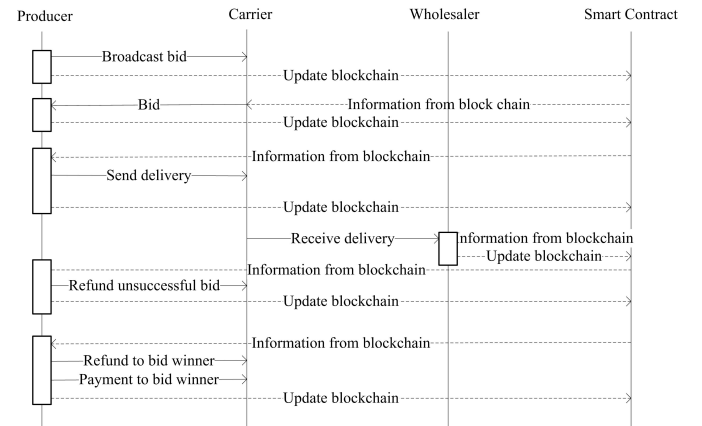


Fig. 3. Transactional scenario for Bidding contract.

TABLE I  
STAKEHOLDERS ROLES AND RESPONSIBILITY

Stakeholder	Role	Responsibility
CA	Central Authority	Owns Provenance Contract; Authorizes the producer
Producer	Produce goods	Introduces product in supply chain; Owns Bidding and Tracking Contract; Sets contract parameter.
C1 to C5	Authorized carrier	Delivers product
C6	Unauthorized carrier	Delivers product

TABLE II  
SMART CONTRACT FOR PROVENANCE

```
//Provenance Contract
// Authorize producer (only CAuthority authorize)
function Authorize_Producer(address _producer)
    onlyCAuthority returns (bool success) {
    producers [_producer].authorized = true;
    return true;    }
// Get producer details
function Find_Producer(address _producer) constant
    returns (string, uint, string, bool) {
return (producers[_producer].name, producers[
    _producer].contactno, producers[_producer].city,
    producers[_producer].authorized);    }
// Get product details
function Find_Product(string serial_no) constant
    returns (address, uint[], uint) {
return (products[serial_no].producer,
    products[serial_no].location, products[serial_no]
    .timeStamp);
}
```

TABLE III  
SMART CONTRACT FOR BIDDING

```
//Bidding Contract
function bid() payable {
require(now <= biddingClose,"Bidding is closed");
// If the bidding period is over, the call is
    reverted
require(msg.value < winningBid,"Bid amount is
    greater than maximum bid value");
// If the bid is not less, the money is sent back.
require(carriers[msg.sender].authorized,"Un-
    authorized carrier");
// If the carrier is not authorized, it cannot bid.
require(carriers[msg.sender].reputationfactor >5,"
    Carrier doesn't meet reputation criteria ");
carriers[msg.sender].bidded = true;
if (winningBidder != 0) {
returnsPending[winningBidder] += winningBid;}
winningBidder = msg.sender;
winningBid = msg.value;
BidValueDecreased(msg.sender, msg.value); }
```

TABLE IV  
SMART CONTRACT FOR TRACKING

```
// Tracking Contract
function receiveDelivery (string trackingNo, string
    _item, uint _quantity, uint[] _locationData)
    returns (bool success) {
// check that item and quantity received match item
    and quantity delivered
if (sha3(deliveries[trackingNo].item) == sha3(_item)
    && deliveries[trackingNo].quantity == _quantity
    ) {
Success('Item received', trackingNo, _locationData,
    block.timestamp, msg.sender);
// execute payment if item received on time and
    location correct
if (block.timestamp <= deliveries[trackingNo].
    timeStamp + contractLeadTime && _locationData[0]
    == contractLocation[0] && _locationData[1] ==
    contractLocation[1]) {
sendToken(deliveries[trackingNo].sender, admin,
    contractPayment);
sendToken(msg.sender, admin, contractPayment);}
```

#### D. Verification of Smart contract

This section presents some scenarios that were used to verify the smart contracts. In blockchain, each stakeholder is represented by a unique address (e.g. 0x1472..160c). The scenario starts by instantiating the Provenance Contract. If the producer tries to authorize itself, transaction reverts to initial state. The wholesaler retrieves product detail, using the find\_product function. Producers address, timestamp of products introduction in chain and products original location can be acquired. As shown in case 5 in Table V, a stakeholder uses the producer's address, to retrieve details of producer.

A carrier can get information of delivery distance or city and maximum bid value calling different functions namely city, distance and maxBidValue. The address of winning bid and the winning bidder is obtained by calling the functions winningBid and winningBidder respectively. A carrier must bid the tender, by creating an instance of Bidding contract, with a bid value that is less than the maximum bid value (initially set 100 ETH as example). The carrier must have a reputation factor greater than 5. C1 to C5 are considered as authorized carrier and C6 as unauthorized carrier. Table VI shows different conditions encountered during bidding. In scenario 1, carrier C1 with reputation factor 8 bids 90 ETH in 100 seconds after bidding is open. It meets the bidding criteria, so the bid is successful.

The owner of Tracking Contract (Producer) sets contract parameter like location, lead time and payment to be received from wholesaler. When producer sends delivery out, it records the details to blockchain. When wholesaler receives delivery, it records the details to blockchain. If it matches the detail initially set by producer, then only the payment is triggered.

#### E. Validation of Proof of Concept

The smart contracts mentioned in Tables II-IV are deployed in blockchain. Different transaction scenario is defined to investigate effects of different behaviours of the stakeholders. To validate the Provenance Contract, a test account is used to simulate the producer and another account to simulate wholesaler. Producer can add its details, as well as its product. Arbitrary latitude/longitude value is used to input location which, in further work, is intended to get from sensors. The scenario is illustrated in Table VII.

TABLE V  
DIFFERENT CONDITIONS OF PROVENANCE CONTRACT

Case	Stakeholder	Address	Purpose	Outcome
1	Producer	0x147..160c	Add producer (P1, Paisley, 96492047)	Can add
2	Producer	0x14..c160c	Authorize producer	Transition reverted to initial state
3	Producer	0x14..c160c	Add product with serial no. and location	Add successful
4	CAuthority	0xca..a733c	Authorize producer (at 0x147...c160c)	Authorize successful
5	Any	0x4b..4d2db	Find producer (at address 0x147c160c)	P1, Paisley, 96492047



TABLE VI  
DIFFERENT CONDITIONS OF BIDDING CONTRACT

Scenario	Carrier	Bid amount in ETH	Reputation Factor	Bid time (+ seconds after bid opens)	Remarks
1	C1	110	8	100	Encounters error as bid value is greater than maximum bid value
2	C1	90	8	150	Bid successful
3	C2	95	6	175	Encounters error as bid value is greater than the new maximum bid value
4	C5	70	4	300	Encounters error as reputation factor is less than the requirement
5	C6	50	7	400	Encounters error as carrier is not authorized
6	C3	80	7	499	Bid Successful
7	C4	60	6	501	Encounters error when attempting to bid after bidding time

TABLE VII  
PROVENANCE CONTRACT SCENARIOS

Scenario	Stakeholder	Address	Purpose	Outcome
1	Producer	0x147...c160c	Add producer (P1, Paisley, 96492047)	Producer is added successfully
	CAuthority	0xca3...a733c	Authorize producer	Authorization of producer is successful

TABLE VIII  
BIDDING SCENARIOS

Scenario	Steps	Carrier	Bid amount in ETH	Reputation Factor	Bid time (+ seconds after bid opens)	Bid Status	Remarks
I	1	C1	110	8	100	Unsuccessful (see Fig. 4)	
	2	C2	95	6	175	Successful (see Fig. 5)	Winner
II	1	C2	95	6	175	Successful	
	2	C3	80	7	499	Successful	Winner
III	1	C3	80	7	499	Successful	Winner
	2	C4	60	6	501	Unsuccessful	

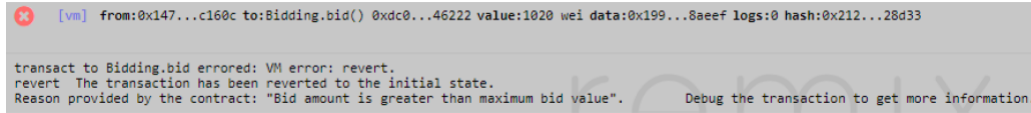


Fig. 4. Error message when bid amount is greater than maximum bid value.

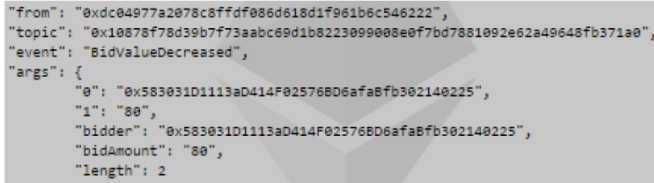


Fig. 5. Successful bid.

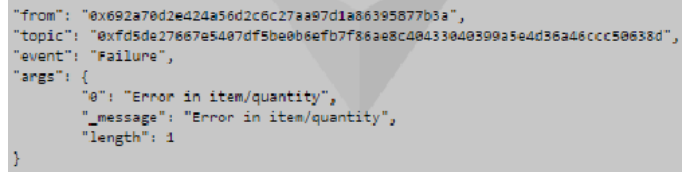


Fig. 6. Error message when received item or quantity does not match.

To validate the Bidding Contract a scenario shown in Fig. 3 is simulated. Different addresses are defined to represent stakeholders presented in Fig. 3 (Producer, Four carriers (C1 to C4), and Wholesaler). Contractual parameters are set as: `_biddingTime`: 500 secs (after deploying contract), `_beneficiary` address: 0xca..733c, `_city`: Paisley and `_distance`: 500 (units)

Table VIII, presents the transactions included in this validation scenario. To validate the Tracking Contract, a scenario similar to the Provenance Contract is simulated. When quantity do not match because of some items missing during delivery, an alert is triggered for necessary actions (see Fig. 6). If items and quantities match, but took longer to arrive than initially set by admin (based on blockchain timestamp), payment is not triggered as predetermined criteria have not been met. Payment

is executed when all pre-set contract parameters are satisfied. The predetermined token amount is automatically sent from the wholesaler account to the admin account.

#### IV. DISCUSSION

We have verified aforementioned contracts with different cases and they run successfully in each attempt. These smart contracts developed for supply chain makes the transactions transparent to the stakeholders. Only the carrier who meets the reputation value and has bid the lowest amount within the bidding period automatically wins the bid and the address of the bid winner and the bid amount is visible to everyone. A stakeholder of supply chain can know the provenance of the product and timestamp of its introduction in supply chain using the provenance smart contract. Tracking of the product



is also possible. This supply chain model ensures transparency and reliability in a bidding process as no any stakeholder can bid before bidding opens or after bidding period.

Transactions are transparent and open. In theory, no stakeholder has chances for fraudulence during the overall process. Nevertheless, the same transparency enables new forms of business risks and ill-spirited behavior. For instance, changes to a Bidding Contract are not possible after it has been deployed to the blockchain. If business conditions change during the Bid time, the Producer cannot react to the changes, until the contract has been finalized. Also, as assignment criteria are open, a malicious carrier can exploit the information about the bidding criteria to make a last minute (second) bid that undermines an honest carrier. We argue that smart contract alone will not able to overcome all the challenges of the supply chain, but contributes for secured transactions maintaining transparency and preventing fraud. The technology has not yet reached its full potential, but research is ongoing to make it more effective.

### CONCLUSION

The use of smart contract along with blockchain technology helped to develop an efficient, secured and traceable supply chain. On top of traceability of product, using smart contracts, transactions are made transparent and determining provenance is possible which enhance security and reduce losses from forged and grey market. The bidding process involved in supply chain is automatized and are made open and transparent.

This paper has proposed a model of a blockchain enabled supply chain. The application of smart contracts to govern a supply chain enables the transparent and automatic actions that guide the interaction among the stakeholders. A proof-of-concept was also presented, detailing the implementation of the blockchain enabled supply chain model in Ethereum using solidity. Evidence of how this proof-of-concept has been verified and validated is also presented in this paper. Our validation efforts show the correct execution of the software. The validation scenarios show that the proof-of-concept can support a typical use case.

Future work will look at how this proof-of-concept can be evolved to support a supply chain in a specific domain like smart grids, or health care or integrated financial transactions. Furthermore, we will look to validate the model by integrating practitioners into our research. Finally, the provided smart contract must be optimized in terms of transactional and network cost before they can be deployed into a live blockchain.

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